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VOLUME VI
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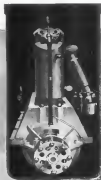
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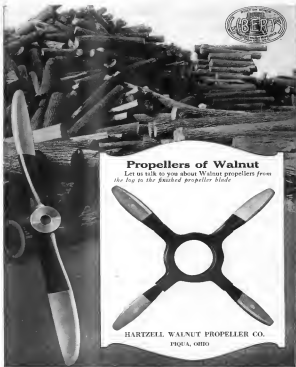
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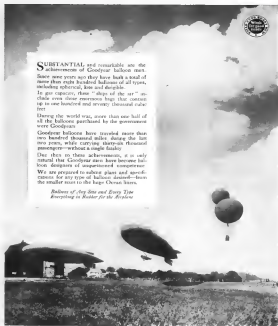


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AVIATION AND AERONAUTICAL ENGINEERING

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AVIATION AND AERONAUTICAL ENGINEERING

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REVIEWER

Vol. VI

July 3, 1919

No. 31

THE first non-stop flight from America to Europe, over a course measuring 13,000 land miles—a new world's distance record—was another stepping stone in the annals of aviation. This splendid performance, achieved by Captain Alcock and Lieutenant Brown in just under sixteen hours flying time, has a significance beyond the mere sporting character of the event.

Viewed as a premier performance, it reveals the first flight across a body of water, the first crossing of the English channel, in 1909, and thus enables us to gain a true perspective of the enormous improvement aircraft have undergone during the last ten years. While progress has outwardly been most notable by the increase in size and performance of airplanes, this has come about without any radical alteration in the general design of heavier-than-air craft. The disposition of wings, the fuselage, the control surfaces, the landing gear, while constructively amplified, remain in general outline what they were ten years ago. What has really improved, is the design and construction of aerobots and aircraft engines.

The development of both these fundamental features of heavier-than-air craft has proceeded in two channels: reliability and efficiency. In the matter of aerobots the pursuit of reliability has resulted in inherent stability, that is, stability achieved without the aid of external mechanical agents, while greater efficiency manifests itself in the high wing loadings modern aerobots withstand without impairing the structural strength or maneuvering ability of the airplane. In aircraft engines the greatly increased reliability is best demonstrated by non-stop flights of many hundred miles, sometimes a thousand and more, while low petrol weight and low fuel consumption illustrate the progress accomplished in the matter of efficiency. The transatlantic flight from Newfoundland to Ireland was, in particular, a brilliant demonstration of engine reliability, although this detracts slightly from the merit of the human element involved—the endurance, pluck and ability of both pilot and navigator.

What the transatlantic flight of the Vickers airplane particularly emphasizes is the very great importance the navigator holds in flights over great stretches of water; and it proves that an airplane can follow a set course across the ocean without requiring the assistance of marking winds or other points of repair. The use of directional wireless will, when this service which is still in its infancy is better developed, make aerial ocean crossings as low reliable than a steamship passage, for the time being, however, it is gratifying to note

that an airplane can safely be navigated across the ocean by reference alone to the heavenly bodies. This is perhaps the most important contribution Alcock and Brown have made to the science of aeronautics by their historic flight.

Screw Propeller Theory

It is most interesting to a propeller designer to be asked from time to time whether he has now evolved his design work to a logical system or whether he is still using empirical cut-and-try methods, basing a number of propellers and testing them in the air till he has on the best one. It is interesting because he has to confess that he is indeed still using theoretical methods and that the result of his experience consists merely in relieving a number of empirical constants, which, applied within narrow limits is propellers of a certain plan form and pitch, will give him fairly good results.

After the great amount of both experimental and theoretical work carried out on propellers such a reply seems rather surprising. That it must be considered that a great many factors enter into the problem. Lanchester and Drenthwick in 1909 first conceived a rational theory in which they assumed each blade element of the propeller as concentrating an aerobal, which the combined velocity of rotation and translation met at a given angle of incidence made easily determinable geometrically.

Given the combined or resultant velocity and the angle of incidence and the aerodynamic constants of the blade element considered as an aerobal, it would appear an easy matter to determine the lift and thrust on the blade element, and hence the thrust and torque components. By a simple process of integration torque and thrust for the entire propeller could be easily found.

But unfortunately this theory runs on the side of simplicity. The air does not meet the propeller at a speed equal to that of the airplane, it has and this has been demonstrated experimentally a velocity relative to the screw larger than the velocity of advance. We could modify the Drenthwick theory to take care of this velocity of inflow, but we do not now know its amount. Attempts to calculate its amount mathematically remain to be verified experimentally.

The complexity of the problem renders almost valueless wind tunnel experiments conducted without careful theoretical basis. But a theoretical basis is difficult to establish without wind tunnel experimentation. It would seem as if there was an extraordinarily large field still to be explored before propeller designs become a simple thing to the aeronautical engineer.

Vickers Vimy-Rolls Crosses the Atlantic



THREE-QUARTER FRONT VIEW OF THE VICKERS VIMY-ROLLS

The Vickers airplane entered for the trans-Atlantic flight competition of the London Daily Mail. Capt. Jack Alcock, pilot, and Lieut. Arthur W. Brown, navigator, succeeded on June 15-16 in making the first non-stop flight across the Atlantic covering the distance of 1916 land miles from St. John's, N. F. to Clifden, Ireland, in 33 hr. 57 min.

According to a statement made public by Captain Alcock, the route was favorable throughout the journey, weathered and at times misty, and account for the high speed—117 m.p.h.—at which the crossing was made. Otherwise atmospheric conditions were distinctly bad, low visibility, fog and rain constantly interfering with navigation, so that only three bearings could be made during the entire flight. As the propeller of the wireless transmitting set ran out of oil shortly after the machine had left Newfoundland no radio messages could be sent from land, and constant guessing of signals not intended for them in fact led to several disastrous messages from being received by the receiver. That under these circumstances the airplane should have hit land at Clifden, which is 40 miles from Galway—where the aviators intended to land—but not more than 10 miles off the course, represents therefore a wonderful piece of navigation.

The Vickers airplane which crossed the Atlantic is presently

being stored in every respect to the standard Vimy-Rolls machine supplied by Vickers Ltd. to the Royal Air Force. The span of both upper and lower planes is 47 ft., the chord 16 ft. 6 in., the gap 16 ft., the overall length 33 ft. 6 in., and the overall height 15 ft. 3 in. The wing area is 1230 sq. ft.

The power plant is composed of two Rolls-Royce High VIII engines, developing 400 hp. and driving two four-bladed tractor propellers. The standard Vimy-Rolls has, fully loaded, a speed of 100 m.p.h. at ground level, 300 ft. p.h. at 6000 ft., and 90 m.p.h., it thinks 5000 ft. is 37 m.p.h., and 50,000 ft. is 48 m.p.h. Fuel for the latter at 30 m.p.h. is carried in addition to a maximum or maximum load of 3000 lb., the latter may be good for carrying eleven passengers and one pilot, or one ton of dead weight, or any combination of the two arrangements.

As the trans-Atlantic model the fuel capacity has been increased to 800 gal. and the oil capacity to 50 gal., which gives the machine an endurance of 2400 miles. The maximum speed is 100 m.p.h., but during the flight across the Atlantic the engine was throttled down so as to maintain an average cruising speed of 90 m.p.h.

The machine is fitted with a radio set capable of sending and receiving messages at a distance of 550 miles, and the pilot and navigator were comfortably heated seats.



QUARTER SIDE VIEW OF THE VICKERS VIMY-ROLLS

Course in Aerodynamics and Airplane Design

Part III.—Experimental Aeronautical Engineering

By Alexander Klemin

Technical Editor, Aviation and Aeronautical Engineering, Consulting Engineer, Aerial Mail Service, Consulting Aeronautical Engineer
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Section 6. Instruments for Full Flight Testing

A great many different types of air speed indicators have in the past been employed for full flight testing. Some of these were pressure instruments with a plate balanced by a spring, rotating vane instruments and hot wire instruments have also been used. At the present time almost all of these types have been discarded, and the use of instruments measuring differences of pressure from two tubes, one giving a pressure the other a suction effect, has become general. Before two Pitot tubes, or a combination of Pitot and Venturi tubes, may be employed for this purpose.

Pitot and Venturi Tubes

In Fig. 1 a Pitot tube is shown schematically. There are two concentric tubes, the inner of which is open to the mouth, while the outer is closed and communicates with the venturi of



FIG. 1. IDEALIZED CROSS-SECTION OF PITOT TUBE

the only by a series of holes. The suction on the outer tube and the pressure on the inner can be read by a pressure gauge which measures the pressure difference between them.

If p is the static pressure of the stream, V the velocity, and D the density, the total pressure on the inner tube is given by the formula:

$$p + \frac{\rho V^2}{2}$$

The outer tube, if the hole is not too small, will be unaffected by the kinetic energy of the stream, and will measure the static pressure p only, while the gauge will register the difference between the two. This will be therefore

$$\frac{\rho V^2}{2}$$

which will be a measure of the velocity.

Pitot tubes are very suitable for wind tunnel work, and can be made to give very accurate results, but they suffer from the defect of very small differences in head. This means that on an airplane it would be next to impossible to read the gauge of a simple Pitot reading.

A combination of Pitot and Venturi will give much more practical forces to measure. Such a combination is shown schematically in Fig. 2, where a proof of the formula for differences in reading is also attached. The advantage of a Venturi tube is that the velocity at the throat is much greater than at the mouth, so that the suction effect is reasonably independent. The reading of the gauge is now due to a difference of pressure of $\frac{\rho V^2}{2}$, and by increasing the ratio of throat area to mouth area this can be increased considerably.

FIG. 2. COMPARISON OF PITOT AND VENTURI TUBES



FIG. 2. COMPARISON OF PITOT AND VENTURI TUBES

Correction for Density of Air Speed Meters

The readings of air speed meters of the above type are therefore proportional to the square of the density and the square of the velocity, and the general equation for this type of instrument is therefore of the form:

$$R = AD^2 V^2$$

where A is a constant depending on the instrument.

In the laboratories air speed indicators are calibrated at 36 deg. Cent. and 760 mm. pressure, and under all other atmospheric conditions they have to be referred to this standard density.

If the instrument gives a certain reading R , at density D , then this reading R will be given by equation:

$$AD^2 V^2 = AD^2 V_0^2$$

and

$$V = V_0 \sqrt{\frac{D}{D_0}}$$

Since

$$\frac{D}{D_0} = \frac{373 + t}{273 + 24} \times \frac{760}{P}$$

$$V = V_0 \sqrt{\frac{373 + t}{273 + 24} \times \frac{760}{P}}$$

$$V = V_0 \sqrt{\frac{373 + t}{273 + 24} \times \frac{760}{P}}$$

TABLE 1

MEASURING FACTORS IN TERMS OF AIR DENSITY AT VARIOUS PRESSURES AND TEMPERATURES IN VARIOUS DENSITY PRESSURES IN MEASUREMENTS OF VELOCITY

Temperature Cen.	200	250	300	350	400	450	500	550	600	650	700	750	800	850	900
100	1.20	1.08	1.00	0.92	0.85	0.78	0.72	0.66	0.61	0.56	0.51	0.46	0.42	0.38	0.34
150	1.10	0.98	0.90	0.82	0.75	0.68	0.62	0.56	0.51	0.46	0.42	0.38	0.34	0.31	0.28
200	1.00	0.88	0.80	0.72	0.65	0.58	0.52	0.46	0.41	0.36	0.32	0.28	0.25	0.22	0.20
250	0.90	0.78	0.70	0.62	0.55	0.48	0.42	0.36	0.31	0.26	0.22	0.18	0.16	0.14	0.12
300	0.80	0.68	0.60	0.52	0.45	0.38	0.32	0.26	0.21	0.16	0.12	0.09	0.08	0.07	0.06
350	0.70	0.58	0.50	0.42	0.35	0.28	0.22	0.16	0.11	0.08	0.06	0.04	0.03	0.02	0.01
400	0.60	0.48	0.40	0.32	0.25	0.18	0.12	0.08	0.06	0.04	0.03	0.02	0.01	0.00	0.00
450	0.50	0.38	0.30	0.22	0.15	0.10	0.06	0.04	0.03	0.02	0.01	0.00	0.00	0.00	0.00
500	0.40	0.28	0.20	0.12	0.08	0.05	0.03	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00
550	0.30	0.18	0.10	0.06	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
600	0.20	0.08	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
650	0.10	0.04	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
700	0.05	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
750	0.02	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
800	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
850	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
900	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

The *densities* can be highly valued by computation, or from the curve of pressure section where densities for varying temperatures and pressures are given as percentages of the standard density, as well as the values of the ratio $\sqrt{\frac{D}{D_0}}$.

Table 1 may be used for approximate corrections. It is based on the assumption of surface standard atmosphere and densities it should therefore not be used for computing performance results, but only as a rough check. In constructing the table a ground level temperature of 16 deg. Cent. is assumed, and a pressure of 760 mm., with a decrease in temperature of 1.75 deg. Cent. per 1000 ft. ascent.

The Fashner-Zakus Direct Reading Air Speed Meter

In Figs. 7 and 8 are shown views of a very widely used modification of the Fashner-Zakus type and the Zakus-Pitot-Venturi tube (now adopted as standard by the Signal Corps).



FIG. 7. FASHNER-ZAKUS DIRECT READING AIR SPEED METER

The pressure lead of the Pitot actuates the small cylinder through the linkage and cone. The velocity is indicated directly by a gage under the aneroid. The action of the Venturi is transmitted to the cone itself. When a difference

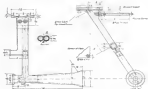


FIG. 8. ZAKUS-PITOT VENTURI TUBE

of pressure exists between the inside and outside of the two cylinders, they diverge or con-
tract. The action is transmitted to the pointer by means of links to a circular rack which engages a pinion on the spindle.

The Tinsman-Leprie Recording Air Speed Meter

In this instrument the Pitot and Venturi tubes are connected to a small recording, called the aneroid by the French. This is illustrated in diagrammatic cross-section in Fig. 9. The projections of the Venturi are so arranged as to give the aneroid pendulous motion for a given air-speed. The aneroid is supported by a thin, helical coiled wire, which also serves to

carry the table transmitting the position to the recording device shown in Fig. 6.

The recording mechanism of the Tinsman-Leprie is shown in Figs. 7 and 8. It has the aneroid on the back and pen. The gage consists of two parallel circular plates, *D*, and *E*, rigidly connected to a rod *AB*. The plates form the tops of

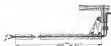


FIG. 9. TINSMAN-LEPRIE AIR SPEED METER

the bellows *f* and *g*. The sides of these bellows are made of flexible, thin rubber, while the bottoms are formed by three plates *m* and *n*. The action from the Venturi is led to the straight chamber *oxy*, and so acts on the top of plate *n*. The pressure from the Pitot is led to the inside of the plate *p*. The top of *p*, and the bottom of *n*, are open to the air inside of the box. Thus a variation of pressure causes no motion of the air, which is acted on by the difference of pressure



FIG. 10. ILLUSTRATION OF TINSMAN-LEPRIE AIR SPEED METER

transmitted from the aneroid. The roll of air is transmitted to wires vertically by the linkage *and* *b*. The link is curved to act on the marking pen *p*, as also a counterweight for the movable parts of the instrument. At the end of the link is a spring *k*, whose tension balances the pressure of the pen. This spring is so placed that the displacement of the pen is nearly proportional to the wind speed. The box

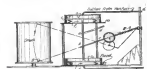


FIG. 11. DIAGRAMMATIC CROSS SECTION OF TINSMAN-LEPRIE AIR SPEED METER

which encloses the recording apparatus is about 2 in. x 6 in. x 5 in., with a total weight of about 4 lb.

It is very important in using the Tinsman-Leprie air speed indicator either in exposed or in sheltered position to have it level by the aneroid. The aneroid position is also of importance, and this should not occur in the alignment of the projection, near the body or anywhere else where disturbances are likely to be violent. The best practical position for the aneroid is

well ahead of one of the outer struts, to which the supporting arm is fastened by tapping or by a special fitting.

However the aneroid is placed, there is also a discrepancy between the readings of the instrument as calibrated in the laboratory and as used on the airplane. A test run in flight



FIG. 12. ILLUSTRATION OF TINSMAN-LEPRIE AIR SPEED METER

must be made over a measured course to check the instrument before every important flight.

Connecting Up an Airspeed Meter

A very simple way of attaching the Pitot tube is shown in Fig. 13, but this is an arrangement open to objection because the strut interferes with the air-flow. It is better to effect the attachment

by connecting the Pitot or Venturi-Tube with the indicator properly flexible aluminum tubing may be used. Besides making all joints airtight it is necessary to avoid sharp bends and kinks. A standard method is called for connection as shown in Fig. 9.



FIG. 13. CONNECTION FOR PITOT TUBE AND AIR SPEED METER

- (1) Slop a 4 in. length of standard rubber tubing, *M*, in line, over the 2 in. length of the 3/32 in. dia. aluminum sheath to meet the end of the rubber tube, extend 1 in. beyond the extremities of the sheath.
- (2) Drill the ends of the aluminum tube and the connection, and slide the sheath on the rubber tube over the joint so that the joint occurs at the middle of the sheath.
- (3) Bend the two ends of rubber tubing with wire. First for the wire near the sheath with a simple knot, leaving one end and free, which is pressed down along the tube and bent under. The wire is wrapped around the tube and when the wrapping is finished the two ends of the wire are twisted together and cut off, leaving a 1/2 in. stick to permit slipping in bending the rubber tube should be taken care to cut it out.

Air-Speed Meter Calibration

While the only real calibration of an airspeed meter is in the air over a measured course, nevertheless laboratory calibration is essential to assure that the instrument has a fair degree of accuracy, and so that errors due to position on the plane must be eliminated. The Pitot tubes and the rubbers are calibrated separately, the former being subjected to the wind tunnel. A standard tube and the tube to be calibrated are mounted on the same stand in the wind-tunnel, and both are attached to water gauges. As the wind speed is varied, simultaneous readings are taken for the two instruments. From these observed data calibration curves are drawn, plotting the observed speed against the speed deduced from the standard pitot-

The indications are converted to velocity or pressure from through water gauges. Then as the pressure is varied simultaneous readings are taken of the indicated airspeed and water height in the gauge. The velocity corresponding to the observed heads can be computed from the formula

$$V = 124.8 \sqrt{\frac{D}{D_0}}$$

where *V* = height of water column in inches at 26 deg. C., *D* = air density in lbs. per cu. ft., *P* = speed in miles per hour. A calibration curve of indicated velocity against observed

TABLE 2

Assumed speed indicated, feet per sec.	Air Speed Conversion of Velocity			
	4,000 ft.	10,000 ft.	15,000 ft.	20,000 ft.
100	100.0	100.0	100.0	100.0
110	110.0	110.0	110.0	110.0
120	120.0	120.0	120.0	120.0
130	130.0	130.0	130.0	130.0
140	140.0	140.0	140.0	140.0
150	150.0	150.0	150.0	150.0
160	160.0	160.0	160.0	160.0
170	170.0	170.0	170.0	170.0
180	180.0	180.0	180.0	180.0
190	190.0	190.0	190.0	190.0
200	200.0	200.0	200.0	200.0
210	210.0	210.0	210.0	210.0
220	220.0	220.0	220.0	220.0
230	230.0	230.0	230.0	230.0
240	240.0	240.0	240.0	240.0
250	250.0	250.0	250.0	250.0
260	260.0	260.0	260.0	260.0
270	270.0	270.0	270.0	270.0
280	280.0	280.0	280.0	280.0
290	290.0	290.0	290.0	290.0
300	300.0	300.0	300.0	300.0

velocity can be plotted from this data. A large number of airspeed meters are calibrated at the Bureau of Standards. First the instrument is tested at room temperature and then the temperature is lowered to -10 deg. Cent. and again calibrated.



FIG. 14. ATTACHMENT OF PITOT TUBE HEAD

at below. This test is repeated at 40 deg. Cent. The permissible variation in reading must not exceed 2.5 m.p.h. After the temperature test the instrument is released on a stand and never calibrated.

Only the briefest outline of calibration methods is given here, as this is essentially the work of a specialist.

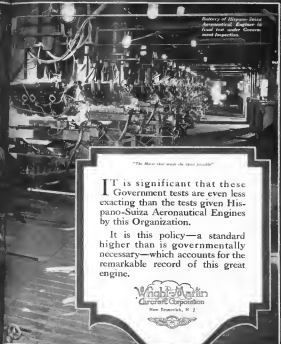
Aeroid Altimeter

The altimeter generally used for measurement purposes are of the aneroid type. Such a barometer contains one or two coils which draw from which the air has been exhausted. The faces of each drum are held apart by a spring, and the coils are fastened to or cut with variations of the atmosphere



HISPANO-SUIZA

Aeronautical Engines



Battery of Hispano-Suiza Aeronautical Engines in final test under Government inspection.

"The Motor that made the speed possible"

IT is significant that these Government tests are even less exacting than the tests given Hispano-Suiza Aeronautical Engines by this Organization.

It is this policy—a standard higher than is governmentally necessary—which accounts for the remarkable record of this great engine.



planes. The requirements to be expected from a good engine design (therefore differ from those of an airplane engine in several important respects):

1. The engine must be suitable for running the very long periods without break-down.
2. All power on the engine must be arranged so that small defects can be made good in the air, the engine, if necessary being stopped for a short period.
3. The fuel used at normal, more particularly at reduced power, are of the greater importance to an engine than is the initial weight of the machinery.

Although there differences between the requirements of airships and airplanes exist at the present time, they will be very considerably reduced as soon as the airplane develops into a machine of engine design and engine size of flying with a smaller proportion of its power. The airship engine requirements of today are very largely the requirements which the airplane will still be to-morrow.

Carrying Capacity

The carrying capacity of an airship is perhaps the feature of greatest importance, both from a service and commercial point of view. The weight, which is available for bombs, gun, stores, merchandise, or fuel, depends upon the volume of gas contained by the ship and upon the weight of the ship's structure and all necessary parts. The volume of gas will increase as the rate of the burner decreases of the ship, and it will be readily understood that the weight of the ship will not increase so much as light power. This indicates that as the size of the ship increases the proportion of her gross lift which is available for lifting capacity will also increase. The non-rigid ship having no hull structure the volume of gas will be considerably greater proportion of available lift. It may be assumed that it is at the present time possible to design both a rigid ship and a semi-rigid ship which will be able to carry as useful load a weight of the ship, 1:1, or 1:1.50 per cent, of the gross lift of the ship will be available for useful purposes. The size of a non-rigid ship will give this ratio is approximately 300,000 cu. ft., and for a rigid approximately 2,000,000 cu. ft.

For many commercial purposes there is much to be gained by carrying a greater weight of useful cargo than that which is one-fifth cargo. For naval purposes when the airship is used as a scout, her function is to carry, observe and transmit telegraphic information for a certain distance in a certain speed, and a ship that will do this with a small crew is as effective as one with a big one. To this it must be added that the small ship can get away on a large proportion of the days when the larger ship would not. The last feature which are available to measure the cost of our largest rigid and non-rigid airships that some out of the advantages referred to above could be had for the same price as the equivalent rigid referred to.

Water Recovery and Use of Hydrogen as Fuel

An airship which is making a long passage extending over several days has to contend with difficulties due to changes of temperature. The change of temperature, and more particularly by the change in the weight of water taken on and lost, is often very great. Let us trace the history of a ship which leaves the ground in the early morning before sunrise.

As the day advances the water up and her lift will probably increase, due to expansion of the gas and the heat of the sun. Then she is prepared to keep herself aloft by using her elevators and flying some down, she must rise and lose gas. Later in the day, when the temperature decreases, the ship will become seriously heavy due to the amount of gas she has lost. It is important, therefore, to reduce the gas loss and it can best be done by avoiding the gas loss by allowing the ship to go to a considerable height. For this it is necessary to take weight into the ship. This can be done by jacking up water from the sea or by condensing the steam formed in the engine exhaust. The first method is only possible in the sea and it is very dangerous to a long height. It even then presents considerable difficulty. There is, however, the advantage that a large volume of water can be produced when required. The weight of the water that can be condensed from the exhaust is theoretical by more than 50 per cent in excess of the corresponding weight of fuel burned in production that has yielded a weight more than about 50 per cent, of the available weight would necessitate very heavy condensers. It is almost certain, how-

ever, that at many times during a long journey it will be necessary to discharge gas and arrangements have therefore been made to use the gas as fuel.

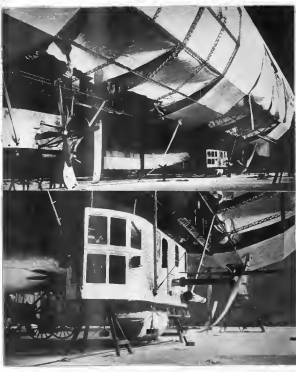
Experiments were first made in burning hydrogen alone as fuel in the engine, but it was found only possible to develop about one-third of the maximum hp. of the engine. It is a greater quantity of hydrogen than this was burnt because direct intake took place in the cylinder. Trials were, however, carried out by using both hydrogen and gasoline, each mixed with the correct proportion of air. By varying the proportion of hydrogen mixture and gasoline mixture, it is possible to obtain all powers up to the maximum of the engine. As the hydrogen gas is only a smaller proportion of hydrogen gas to be burnt with oil inside. No serious difficulties were experienced with the use of hydrogen as fuel, but it has been considered desirable that the gas should be drawn from the reservoir of a pressure less than atmospheric in order to avoid any possible risk of fire. A spring-loaded non-return valve in which is the hydrogen discharge pipe and is located in a structure considerably in excess of that which will ever be obtained in the envelope. The motion of the engine is sufficient to draw the hydrogen through the valves, but if for any reason the engine stops no further hydrogen passes. The apparatus has been most thoroughly tested in elastic risk due to fire, and it appears quite certain that at the present time the risks from a hydrogen fire with the gas are quite negligible.

Types of Airships Developed During the War

The present classes of British airships have been gradually developed from the beginning of 1915, when the interest in airships was revived by Lord Fisher's decision that they might be made to form an important part of the naval armament. The first B-5 ship was constructed by suspending a B-10 airship, stripped of its wings and tail, under a suitable small envelope. The trials of the first ship were made in less than twenty days from the time the instructions to proceed were received. The first flights were so satisfactory that the Admiralty gave instructions that the production of these ships was to proceed at once. The B-10 class of airships suffered very slightly from the original ship in certain respects which had been found desirable in the first trial. A few one of the greatest type which generally consisted of a large nose, four funnels, were constructed by a private firm, but although they retained the plan of the prototype ship, they did not prove as satisfactory as the other B-10 type.

It soon became necessary to construct a ship of larger size and capable of lifting a greater load and of longer endurance. An envelope of the "A" type was obtained from a ship which had been badly damaged by fire in a Belgian military air park. A suitable one to take their new was manufactured and rigged below it. This again proved a satisfactory gas-tight envelope and was the beginning of the Coastal type. This envelope had to be redesigned, but the modification made to the air were comparatively small. This class of ship was modified in 1928 to the type known as C-1 (Coastal class), which had some a better shaped envelope and slightly better open accommodation at the rear.

A ship larger than that the Coastal was found to be required for extensive cruising in the North Sea and in the North Atlantic, and the B-10 ship was, therefore, designed. This class is a distinct departure from the earlier classes, but its history is in a kind quite separate from the main one, which is our chief concern. The crew and operating parties were carried by this ship mounted, under certain circumstances, to about three times, and the distribution of this load concentrated in very interesting problems. In the early days it was necessary a number of tanks attached to either side of the top ribs at a convenient distance above the top edges. Access to tanks was obtained by climbing the gas tubes, which were up through the centre of the ship, and then down a ladder way to a walking way along the top edges. It was not, however, considered desirable that a man should have to be sent up to top of the ship every time it was desired to turn down an additional gas tank and arrangements were made to lead wires from the power cable round the surface of the envelope to each petrol tank. This method operated in the early days, but was experienced with the low carrying the gas from the tanks in the air. The weight involved in the whole installation was also considerable. An alternative scheme was therefore devised in the next ship and provided large 50 gal. gasoline tanks drawn up through the under surface of



Portion of the Rigid Envelope to Show the Gas Bags, and Use of the Gas in the Rigid British Rigid Airship B-29. General Jones Photo Service.

The New Navy General Specification for Airplanes

By Archibald Black

Aeronautical Mechanical Engineer, Navy Department

The new edition of the Navy General Specification for Airplanes (The 300-A), just issued, has been very completely revised and contains many changes in its details. This new edition is divided into five distinct sections (each covering a different phase), as appendixes and a detailed index. Three parts include amendments only on subject matter which has been added to or changed materially from that in the previous issue.

Section I

Section I covers substantially the same ground as the corresponding sections of the previous issue. The sections have been rearranged, however, and some minor changes have been made.

Performance subdivisions (Part 12) are required to be based on standard density, using the value 0.00186 per sq. ft. for the weight of air. An "aircraft tests are made" reported on such a basis, this requirement simply serves to hold engineers to a definite and accepted standard.

Section II

Section II shows a number of changes, many of considerable importance, and the majority of which have been made with a view to facilitating production and reducing the confusion often caused by changes in design.

Assembly gage (Part 41) are required to be approved by the Navy Inspector. This requirement is made because of the provisions in Section IV, for the acceptance of parts such as wing panels, etc., without their being assembled.

Production gage and changes (Part 42 to 49)—Production gage is now required to be checked on under a series of factors which, each carrying a percentage of the entire under, this percentage is to be specified in contracts hereafter. This is, of course, the existing practice in many plants, but is now being made a requirement for all new designs. The factors are divided into classes: (a), (b), (c), (d), as associated with their importance, and definite rules are laid down as to when and how for such changes must be presented in accordance with production, and as such factors (other than (a)) are to be used. This arrangement should go a long way toward clearing up some of the difficulties formerly encountered in checking changes during production.

Weighting of parts (Part 43, 44, 45) before receipt is required on the first three machines as an airplane, or the first three subassembly changes from the type originally called for by the contract. The center of gravity of each part is also required to be ascertained. The Department Inspector is authorized to require the weighting of parts subject to approval from the regular production office, for the purpose of ascertaining if the original weights are being maintained.

Inspection Gaskets (Part 47) covering the stresses and maintenance of materials in the field are required to be designed with such machines.

Changes of Wing Panels, etc. (Part 49) are now required to show the stress in square feet for each inch. Such drawings are now required to state the capacity of each inch in U. S. gillions.

Section III

Section III contains many technical changes—particularly in the requirements relating to power plants.

Wings and portions (Part 36 to 37)—Water-tight subdivisions of hulls and portions is required, but now made as left for the acceptance of modifications such as the H-16 type of hull. Draw plans are required on all floats or water-tight sub-divisions of hulls of any kind. Hulls must not less than 4 in. in diameter are required similarly, excepting in the case of monohull floats constructed of metal.

Water pumps or other means are required (Part 40) for pumping water out of any compartment of diving hulls when under way.

Water pumps (Part 41)—These are required on hulls and portions when necessary, and their outlines are required to be placed on drawings.

Propeller clearance (Part 48 to 49) is governed by the

type of machine and the service for which it is intended, the following minimum clearances being required:

Lead type machine clearance between propeller tip and ground: $\frac{1}{2}$ in. for machines with a propeller tip speed of 100 ft. per sec. or less; $\frac{3}{4}$ in. for machines with a propeller tip speed of 100 ft. per sec. or more.

Water type machine clearance between propeller tip and water: $\frac{1}{2}$ in. for machines with a propeller tip speed of 100 ft. per sec. or less; $\frac{3}{4}$ in. for machines with a propeller tip speed of 100 ft. per sec. or more.

Water type machine clearance between tips of propellers: $\frac{1}{2}$ in. for machines with a propeller tip speed of 100 ft. per sec. or less; $\frac{3}{4}$ in. for machines with a propeller tip speed of 100 ft. per sec. or more.

Water type machine clearance between tips of propellers: $\frac{1}{2}$ in. for machines with a propeller tip speed of 100 ft. per sec. or less; $\frac{3}{4}$ in. for machines with a propeller tip speed of 100 ft. per sec. or more.

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Control Pulleys are permitted to have (Part 205) either ball bearings or self-lubricating bearings. Self-lubricating ball bearings have the advantage that they need practically no attention after being installed, and are preferred by some manufacturers, but were formerly not accepted by the Navy Department.

Automatic oiling—Automatic oiling is required to be at least 3 ft. 6 in. from the engine (Part 333).

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ing parts are required to be interchangeable with under parts from one machine to another of the same model:

(1) Back structural wing parts, complete wing ribs, etc.

(2) Control assemblies, wing struts, other rigging, etc.

(3) Airframe (complete).

(4) Landing gear (complete).

(5) Engine (complete).

(6) Propeller (complete).

(7) Vertical fin (complete).

(8) Fuselage (complete).

(9) Wings (complete).

(10) Landing gear (complete).

(11) Engine (complete).

(12) Propeller (complete).

(13) Vertical fin (complete).

(14) Fuselage (complete).

(15) Wings (complete).

(16) Landing gear (complete).

(17) Engine (complete).

(18) Propeller (complete).

(19) Vertical fin (complete).

(20) Fuselage (complete).

(21) Wings (complete).

(22) Landing gear (complete).

(23) Engine (complete).

(24) Propeller (complete).

(25) Vertical fin (complete).

where the fabric is applied to the surface are required. This method of application also has the advantages of facilitating production and saving a little money.

Attachment of fabric to ribs is required to be accomplished by means of the lacing method, which is practically in general use in this country at present. The lacing around ribs, however, are required to be not more than 2 in. apart, and either a cotton strip or manila rope required to be used under the lacing.

A close weaving of struts is not permitted (Par 206), this being based upon the results of investigations which show that such weaving did not increase the strength of the struts and gave a slightly lower strength for the same strength. The use of a band of tape about the mid portion of unweaved struts is, however, required as a slight additional protection against failure due to faulty weaving. This tape is required to be oriented in place with the (preferably round) as tape has been found to be of little or no value for fastening of fabric to wood.

Shaping and finishing of wings (Para 300 to 302) is now required to be done by applying two coats of cellulose acetate dope, followed by two to four coats of cellulose acetate dope, after which the surfaces are required to be finished with Naval Dope enamel, two coats of enamel being given to all vertical surfaces and to upper sides of horizontal surfaces and one coat to the lower sides of horizontal surfaces. (Note that specification was issued, the Navy Department (on consideration of the fact that low visibility is not of importance under present conditions) has waived the usual gray enamel finish in favor of an aluminum finish, which, in its highly reflective qualities, greatly decreases the temperature of the fabric in southern climates, thus prolonging its life.)

Conformity or non-conformity of new the kind of plating given (Para 310 to 313), although any method of applying this plating may be used. It has been found to be the only metal which affords satisfactory protection to steel against corrosion.

External structural wires, cables, etc., are required to be coated with spirit varnish coated with Chinese blue (Para 314).

External structural wires, cables, etc., are required to be painted with Naval Dope enamel (Para 315).

Control wires are required to be coated with an approved grease (Para 308).

Section VI

Acceptance of production machinery—Provision is made (Para 322 to 325) for the acceptance of production machines without their being completely assembled, provided that proper tests are used. The acceptance tests include:

1. The acceptance of the power plants when the design of the machine is given.

Section VII

This section contains several reference tables on the strength of struts, including a table (No. 31) giving the strength of tapered struts in relation to that of parallel struts. A table of struts and weights, etc., of a number of different woods is also given.

Twist—The twist is a new feature which was found necessary on account of the difficulty of twisting, and will no doubt be found very helpful in locating irregularities.

Desirable Developments

The equipment portion of the Engineering Division, Air Service, has certain developments, etc., which they desire to develop. The following list is granted in order that inventors and designers may become familiar with some of these problems.

Weather Straps—A strap is desired which will withstand a pull of fifteen tons free at a range of thirty yards, the strap consisting of cellulose 34, equally sized, seven, rayon, paraffin, and kerosene treated. The strap should be the most valuable such without fire occurring, is in the maximum state as an actual basis. However, the strap should be kept in just as it is and the maximum pull should be about 75 per cent more than the actual standard test weight. Information will be furnished to anyone who desires it.

Oil Ray (Flame, London, 1918, etc.)—The object of these devices is to prevent machines from exploding when landing in



REARVIEW PERS. OF MACHINE, WITH 150 H.P. ENGINE ROOM, REARVIEW

gallon. At present, the mounting for the engine can be left on the tank, as it is thought that the mounting on the tank board will offer less many complications, unless done electrical by.

Control Electric Power Plant—This is a motor the design of a motor generator and battery which will furnish the power required for the radio installation, the lighting and lighting installation, together with the necessary, perhaps, more forms to supply these various apparatus with the electrical energy needed in the preparation and test. This is to be engine driven in some way and this will do away with the need of resistance of the various and drive generators now used. Of course this unit, as a most easily will, contain a motor in weight.

The motor for which this is most desired are the Liberty-12 and the Hispano-Suiza 200 hp. Two ideas are desired, viz. the application to engine driven generator and simpler design to be incorporated in engine to be produced in the future.

Mobile Independent Charging Device—This device is to be an electrically driven charger for planes and equipped with self-starters and is to be mounted on a motor truck. It is to be used in emergencies in the following manner: the truck would be hooked up to the front end of any airplane, a flexible arm attached to the propeller, and the electric energy be brought into play to crank the engine and start the engine to flight.

When the engine starts, the device should be automatically thrown out of connection with the power plant.

New World's Height Record

Sub-Laurelton, Canada, at the French Air Service, who established on June 2 a new world's altitude record by reaching an altitude of 6,000 ft. (31,167 ft.), broke his own record on June 34 by climbing 10,191 ft. (33,280 ft.) in one day. The machine used on the first of these flights was a Nieuport Type 29 biplane, fitted with a 260 hp. Hispano-Suiza engine.

First Municipal Aerodrome

The Airy Chamber of Commerce, through its executive committee, has announced the location of the new Municipal Aerodrome, which is to be located on the site of the old Municipal Aerodrome in the city of Albany, N. Y. It is a former landing field and is provided with devices for showing the direction of the wind. A statement is made that it is a first landing field and an intention is now being made to drop in Albany.



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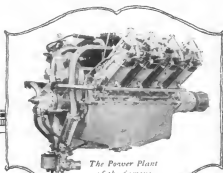
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